

Habitat use of the threatened Booroolong Frog (*Litoria booroolongensis*) in the Central West Catchment Management Area

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ABSTRACT

The endangered Booroolong Frog *Litoria booroolongensis* has undergone dramatic declines over the majority of its range, which have largely been attributed to extensive clearing and ongoing modification associated with agricultural practices, disease and introduced pests. This paper presents a small-scale assessment of the distribution and habitat associations of the Booroolong Frog, using data collected during surveys for environmental impact assessments, in areas of likely preferred habitat identified along the Campbells and Macquarie Rivers south of Bathurst and the Turon River at Sofala New South Wales. Seven stream reaches were sampled within study areas, and the Booroolong Frog was recorded in four of those. Thirty-four Booroolong Frogs were recorded, by direct observation and call play back, usually in habitat typically associated with the species. Seven of these were found in highly degraded habitat reinforcing similar observations for this species in the literature. Field data collected during this study and the resulting habitat information will add to the knowledge of the distribution and habitat preferences of this threatened species. This study also provides recommendations to assist in the development of appropriate conservation management actions within the area.

Key words: amphibian, survey, endangered, distribution, wild population, disturbance

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Introduction

The Booroolong Frog *Litoria booroolongensis* is an endangered species listed under both NSW and Commonwealth legislation. It historically extended from the Queensland border, south down the Great Dividing Range and into north-eastern Victoria (Anstis 2014; Hunter 2007; OEH 2016; Gillespie and Hines 1999 and DotE 2016). Since the mid-1990's, however, it has disappeared from more than 50 per cent of its former known range (OEH 2016). Known populations of this species are isolated and it is rare throughout the remainder of its range (Heatwole et al. 1995; Gillespie and Hines 1999; Murray and Hose 2005; Hunter 2007; OEH 2016). The main cause of decline for this species is considered to be chytrid fungus (*Batrachochytrium dendrobatidis*). Additional pressures for the species include modification and loss of streamside habitats, water pollution, use of pesticides and herbicides, drought and predation by introduced fish, such as European Carp *Cyprinus carpio* and Mosquito Fish *Gambusia affinis* (Regan 2002; Hunter et al. 2011; DotE 2016 and Hunter 2012). Given these rapid population declines and continuing decline in the extent and quality of its habitat, there has been considerable attention paid to this species, resulting in its listing as an endangered species, conservation management of the species habitat (primarily focussed on riparian restoration and livestock and weed management), captive breeding and reintroduction programs, and a national recovery plan (DotE 2016; OEH 2016).

Considerable work has been undertaken on the habitat requirements of the species (DotE, 2016). However, while recent surveys have identified persistent populations in a number of streams in New South Wales (NSW),

there is limited information available on the extent of these populations in the Central West catchment (OEH 2016). Conservation works, including stock restrictions in the riparian zone, weed control and eradication and re-establishment of native riparian vegetation (Hunter and Smith 2013), are being carried out for some populations in NSW. While populations have been identified in the Turon and Campbell's rivers, no published surveys have been carried out for populations along the Macquarie River near Bathurst (DotE 2016).

Available evidence indicates that the Booroolong Frog requires extensive rocky structures along a stream, with some fringing vegetation (Anstis et al 1998; Alford and Gillespie 1998; Gillespie and Hines 1999). Adults occur on or near cobble banks and other rock structures within stream margins, or near slow-flowing connected or isolated pools that contain suitable rock habitats. Females deposit eggs in the crevices of the rock structures within the shallow slow to medium flowing sections of a stream, or in adjacent slow flowing connected or isolated rock pools (Anstis 2002; Hunter 2007; DotE 2016). Studies by Hunter and Smith (2013) found a negative relationship between increasing canopy cover and the species occurrence, likely relating to thermoregulatory requirements impacting growth rates and increasing exposure to disease pathogens such as chytrid fungus. According to Hunter and Smith (2013), exotic trees, such as willows, were more likely to reduce species occurrence compared to native trees, relating to their denser canopy cover reducing the temperatures of the microhabitats below.

The dispersal capabilities and non-breeding habitats of the species are unknown, but the species is likely to be relatively sedentary (DotE 2016). Hunter (2011) found that the majority of recaptured individuals moved less than 50 metres within a season, with maximum movements of up to 300 metres being recorded across seasons (DotE 2016).

The Booroolong Frog has been found to persist in sections of streams that have been highly modified, devoid of native vegetation and open to stock access, as well as within artificial structures such as weirs. Such high levels of disturbance are however, unlikely to be conducive to long term persistence (Hunter 2007; Antsis et al. 1998; DotE 2016).

Here we report on the discovery of a population along a stretch of the Campbells River downstream of Chifley Dam and along the Macquarie River upstream of Bathurst in habitat where the species has not been detected for decades (OEH 2014). In addition, the habitat requirements of another population identified along the Turon River at Sofala is also discussed. The abundance, distribution and habitat associations of the individuals found are discussed. Both sets of surveys were undertaken as part of environmental impact assessments for the Bathurst Regional Council.

Methods

Study areas and site selection

Targeted surveys for Booroolong Frog were carried out along the Macquarie River and Campbells River to the south of Bathurst, and the Turon River at Sofala, in order to identify potential impacts on native biodiversity values of projects proposed by Bathurst Regional Council (see Figure 1). In Bathurst, surveys were carried out to inform pipeline route selection between Chifley Dam and the Bathurst Water Treatment Plant, while in Sofala the surveys were carried out to inform flood mitigation works.

The northernmost part of the Bathurst study area was the intersection of the Macquarie River and Kendall Avenue, in east Bathurst, and the southernmost part located at Campbells River just downstream of Chifley Dam. This study area was located mainly in the Bathurst local government area (LGA), with a small area near Chifley Dam within the Oberon LGA. The other study area was located along the Turon River immediately adjacent to the township of Sofala. This second study area is located at the boundary of Bathurst LGA and Mid-Western LGA. The Bathurst study area is within the Bathurst subregion of the Central West Catchment Management Area (CMA), while the Sofala study area is within the Hill End subregion of the Central West CMA. Both are within the South Eastern Highlands Bioregion.

Twenty-eight populations of the species are known, and while some of these populations occur in the Central West catchment area, interestingly, only one individual frog has been recorded near the Macquarie River (from the year 2000 (OEH 2014); DotE, 2016).

The list of local population information for this species

does not include the Macquarie River (DotE 2016). A population is known to occur about 20 kilometres upstream of Sofala (OEH 2014). Previous records of the Booroolong Frog held in the NSW Atlas of Wildlife and Council's threatened species database were reviewed in order to determine the species' distribution in the locality (OEH 2014).

Aerial photographs of the two rivers were reviewed to identify areas where preferred aquatic cobble habitat (Hunter 2012; Hunter & Smith 2013) was likely to be present. Identification of cobble habitat was used to assist with focussing survey effort (see below).

Survey methods

Bathurst survey period and weather conditions

The investigation areas for the Booroolong Frog surveys are shown on Figure 1. Surveys near Bathurst were conducted in November 2012 and November 2013. The November 2012 survey focussed on a wide range of fauna and flora species, and targeted surveys were restricted to about one hour of Booroolong Frog searches on two evenings. Due to the identification of the species in this study area, additional targeted surveys were conducted in November 2013. These surveys consisted of four hours of surveys for each of four nights. All surveys focussed on areas of rocky and cobbled habitat along the rivers.

Surveys in November 2012 were undertaken from the 5th to 8th of November. The weather was hot at the beginning of the week, and cooled towards the latter part of the week. Daytime highs ranged from 22.4°C to 29.6°C. Overnight lows ranged from 6.9°C to 15.4°C (BOM 2013). Between 1mm to 4.4mm of rain fell towards the latter part of the week.

Surveys in November 2013 were undertaken from the 25th to 29th November 2013. The weather was mild at the beginning of the week and hot at the latter end of the week. Daytime highs ranged from 23.4°C to 32.1°C. Overnight lows ranged from 5.5°C to 16.8°C (BOM 2013). No rain fell during the week, however there had been rain the previous Friday (9.4mm).

Sofala survey period and weather conditions

The targeted surveys near Sofala were undertaken from the 14th to 15th of January 2015. Surveys lasted about two hours each. Weather was mild for the entirety of the survey period. Daytime highs ranged from 23.5°C to 25.6°C. Overnight lows ranged from 10°C to 18°C (BOM 2013). Up to 9.4mm of rain fell at the beginning of the survey, drying off for the latter part of the surveys.

Methodology

Various reaches where cobble habitat was present were surveyed within the two study areas. The length of each reach surveyed depended on presence of cobbles or rock structures and access constraints. Active streamside searches and spotlighting for frogs were undertaken at each survey site focussing on areas where cobble habitat was likely to be present. Creek banks and streamsides with connectivity to cobble (rock) banks and other rock

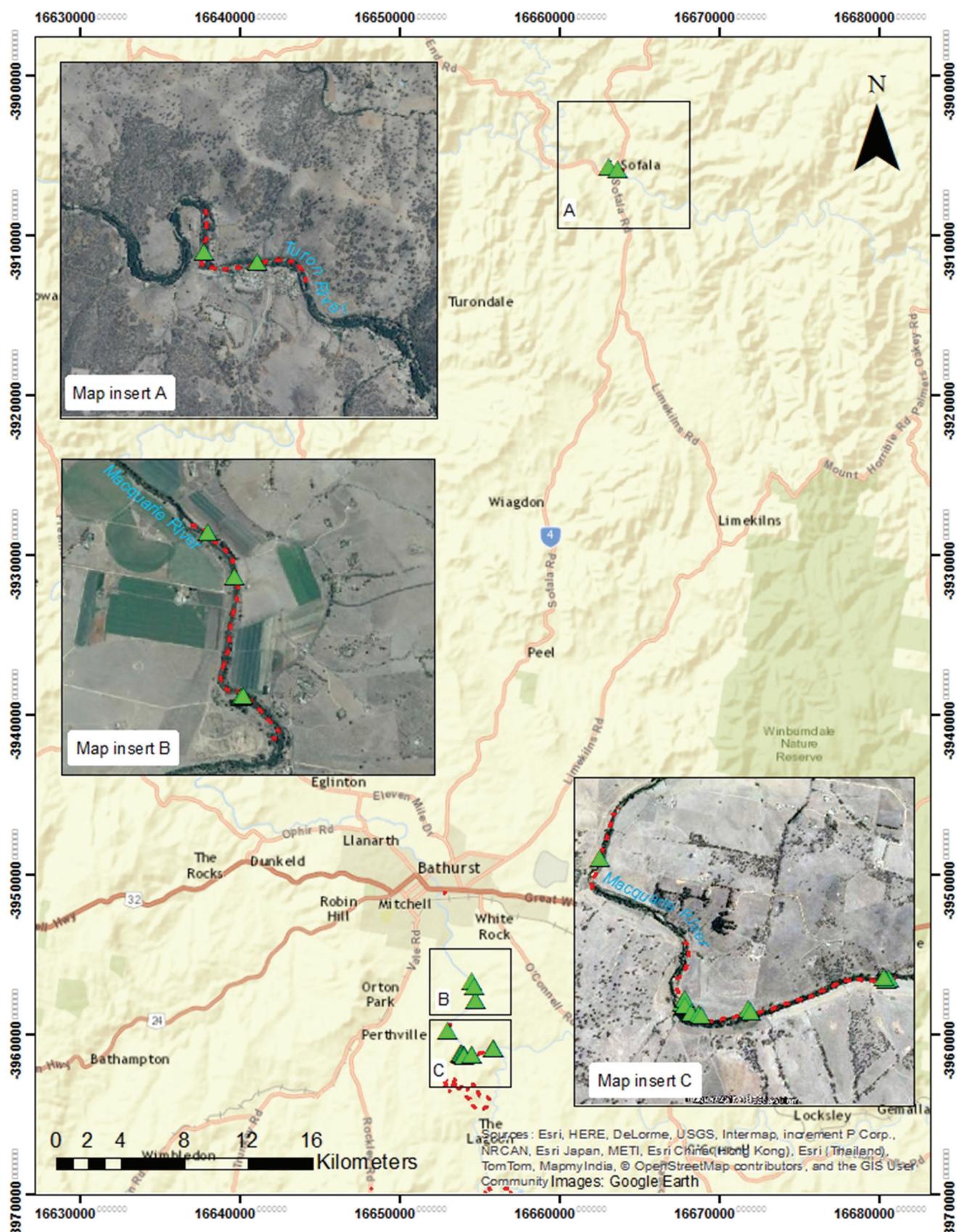


Figure 1. Map of Booroolong Frog records captured during all surveys. Green triangle shape symbolises a Booroolong Frog record and red dashed line indicates a transect line.

structures within the stream margins were systematically searched and semi-aquatic vegetation was visually scanned. Frogs were identified by sight and call. Calls of the Booroolong Frog were also broadcast at each survey site, comprising a minimum of five minutes calling followed by at least a ten minute listening period.

Frogs were only hand captured if their identification required confirmation; particularly in areas where the frog had not been previously recorded. Individuals were handled for less than 30 seconds, in accordance with the survey guidelines and hygiene protocols (DECC 2008).

Opportunistic and incidental observations of other fauna species were recorded at all times during field surveys, as well as while travelling to and from survey sites.

Results

Survey locations and effort, number of frogs recorded and observed habitat are shown in Tables 1 and 2 and Figures 1 and 2.

Species distribution and abundance

Bathurst surveys

Of the seven reaches surveyed, four were found to contain the Booroolong Frog (see Table 1 and 2).

Near Bathurst, all records were from the Macquarie River. During the initial 2012 survey, one individual was observed on one evening in a wide expanse of cobbles along the Macquarie River. No Booroolong Frogs were recorded in the survey conducted immediately downstream of Chifley Dam. During the targeted surveys in November 2013, individual Booroolong Frogs were heard calling on three of the four survey nights, along the immediate bank inspected and on the opposite banks, in

response to playback of recorded vocalisations. Again, no Booroolong Frogs were recorded along the sections of Campbells River that were surveyed.

Twenty-nine Booroolong Frogs were recorded foraging, or traversing along the edge of open emergent cobble banks, sand banks and small areas of vegetation at the three survey sites along the Macquarie River. Locations with Booroolong Frogs are shown in Figure 1.

Booroolong Frog sightings ranged from 1.2 to 2.6 km apart along the river (refer to Figure 1).

Sofala surveys

Three Booroolong Frogs were recorded in or adjacent to cobble areas near Sofala (see Tables 1 and 2). At least two were heard calling, also from cobble banks. This study area was much more restricted in area, with individuals recorded over a distance of about 500 m.

Near Sofala, Booroolong Frogs were observed downstream of Crossley Bridge on one evening and immediately adjacent to the main Sofala township on the second evening. Frogs were also heard calling on the second evening. On both nights, the frogs were recorded in or near cobble banks. Photographs of frogs and associated habitat are provided in the photo plates in Figure 2 (photographs 13 to 16).

Habitat associations

During the November 2013 surveys at Bathurst, individuals observed at two sites ranged in life stages from froglet, sub-adult to adult frog, suggesting that breeding, or at least juvenile dispersal, was taking place. Locations where juvenile and sub-adult individuals were observed comprised typical breeding habitat, including extensive and exposed cobble banks with rock crevices, and adjacent pools with some fringing *Typha* and *Baumea* species (photograph 11

Table 1. Survey effort, location and transect length related to habitat observed in Table 2.

Region	Date	Effort	Location	Frogs present	Transect number	Total transect length (kms)	Figure 1 reference
Bathurst	5/11/2012	2 hours	Campbell River immediately below Chifley Dam	No	6	1.1	-
	8/11/2012	2 hours	Macquarie River near Montavella Rd, Gormans Hill	Yes	2	1.70	Map inset B
	25/11/2013	4 hours	Campbell River below Chifley Dam	No	5	0.78	-
26/11/2013	4 hours	Macquarie River upstream from Montavella Rd, Gormans Hill	Yes	2	1.70	Map inset B	
			Yes				
27/11/2013	4 hours	Macquarie River near Bidgeeribbin Rd, The Lagoon	Yes	3	0.78	Map inset C	
			Yes				
28/11/2013	4 hours	Macquarie River near the southern end of White Rock Rd, White Rock;	Yes	4	2.52	Map inset C	
			Yes				
Sofala	14/01/2015	2 hours	Bicentennial River Park, Bathurst.	No	1	0.29	-
			Yes				
	15/01/2015	2 hours	Turon River, west of Crossley Bridge	Yes	7	1.4	Map inset A
			Turon River, east of Crossley Bridge	Yes	7	1.4	Map inset A

Table 2 Number of frogs observed, observation type and habitat association. ○ = known preferred habitat; ● = known threats (as described on the species profile (OEH 2016). Transect number relate to those in Figure 1. Photo numbers those labelled as such in Figure 2.

Transect number	Number of frogs located	Photo number	Observation type	Habitat observed
1	NA	NA	NA	<ul style="list-style-type: none"> ○ Cobbled banks ○ Emergent vegetation ● Disturbed (erosion) stream bank ● High stream flow ● Adjacent to mown grasses and recreational areas ● Public access ● Domestic dogs present
2	5	3&4	Direct; sitting at water's edge, and in clumps of vegetation	<ul style="list-style-type: none"> ○ River oak riparian open woodland
	4	1 &2		<ul style="list-style-type: none"> ○ Fringing vegetation cover, mainly sedges
	1 (2012 survey)	NA	Direct, observed sitting on cobbles	<ul style="list-style-type: none"> ○ Cobble outcrops ○ Moderate stream flow
3	2	NA	Heard; in emergent vegetation along river bank edge	<ul style="list-style-type: none"> ○ River oak riparian open woodland ○ Fringing emergent vegetation ● Trampled banks (cattle) ● Heavily infested with weeds
4	12	9-12	Direct, observed on sandbank and in shallow water	<ul style="list-style-type: none"> ○ Permanent streams adjacent to pools ○ River oak riparian woodland ○ Extensive cobble banks in stream margins ○ Fringing vegetation
	3	5&6	Direct, observed sitting amongst aquatic macrophytes amongst large emergent boulders	<ul style="list-style-type: none"> ○ Large boulders ○ Grassy fringing vegetation ● No submerged cobble stones or smaller rock crevices ● Heavy weed invasion ● Water impoundment ● Damaged stream margins by cattle
	2	7&8	Direct, observed in water at the edge of a sandbank	<ul style="list-style-type: none"> ○ Isolated pools adjacent permanent stream ● Sedimentation ● Modified cobble banks ● Water impoundment ● High weed invasion by blackberry ● Algal blooms
5	NA			Open forest
6	NA			<ul style="list-style-type: none"> ● Introduced fish present – carp ● Modified stream bank ● Weed invasion
7	3	13 to 16	Direct; sitting at water's edge on an area of cobble bank	<ul style="list-style-type: none"> ○ Permanent streams adjacent to isolated pools ○ Open woodland ○ Extensive cobble banks in stream margins ○ Fringing vegetation

Figure 2 Booroolong Frogs observed during the November 2013 surveys in Bathurst (photographs 1 to 12) and January 2015 surveys in Sofala (photographs 13 to 16) and the associated habitat features they were found in.



Photograph 1: Booroolong Frog observed in adjacent stream and rock habitat shown in photograph 2.



Photograph 2: Rock outcrop where Booroolong Frogs were observed.



Photograph 3: Booroolong Frog observed in rock habitat shown in photograph 4.



Photograph 4: Rock outcrop where Booroolong Frogs were observed.



Photograph 5: Booroolong Frog observed on aquatic macrophytes amongst large emergent boulders as shown in photograph 6



Photograph 6: Boulder (rocky) habitat where a Booroolong Frog was observed. Large boulders and grassy fringing vegetation. No submerged cobble stones or smaller rock crevices. Heavily weed infested. Water impoundment in sections and damaged stream margins by cattle.



Photograph 7: Booroolong Frog observed within a stagnant pool within a sand bank. Larger area shown in photograph 8. Area was heavily infested with weeds and dense mid-storey vegetation.



Photograph 8: Stagnant pool where a Booroolong Frog was observed. Isolated pools with algal blooms, adjacent permanent stream. Sedimentation. High weed invasion by blackberry.



Photograph 11: Juvenile Booroolong frog observed in stream and rock habitat. Several individuals of various life stages were observed in proximity to this individual. Habitat shown in photograph 12.



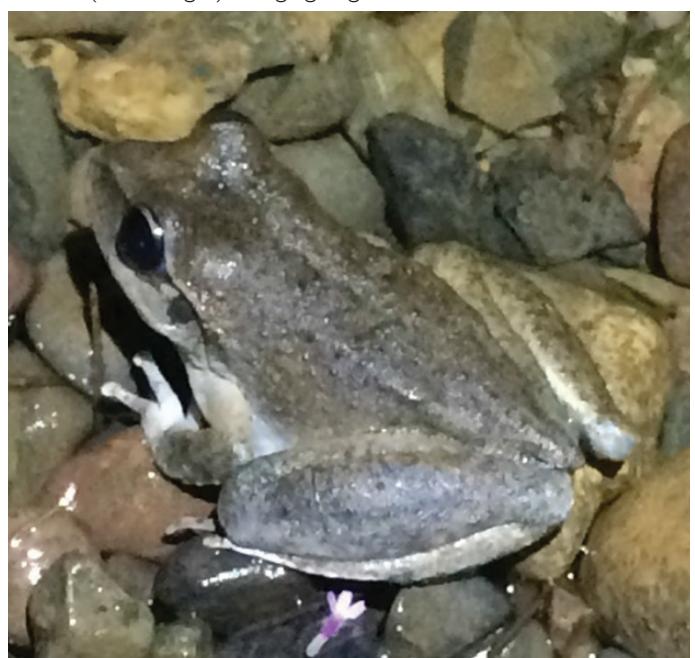
Photograph 9: Booroolong frog observed traversing sand bank with sparse rocky cover as shown in photograph 10.



Photograph 10: Sand bar with sparse rock cover.



Photograph 12: Densely cobbled habitat adjacent to stream (to the right). Fringing vegetation.



Photograph 13: Booroolong Frog observed amongst a small area of cobbles at the far end of the pool shown in Photograph 14.



Photograph 14: Cobble habitat where the Booroolong Frog shown in Photograph 13 was observed.



Photograph 15: Boorolong Frog observed amongst cobbles on a stream bank.



Photograph 16: Habitat where a Boorolong Frog shown in Photograph 15 was observed.

and 12). Tadpoles were noted at one location within a small pool adjacent to cobble banks and in close proximity to Booroolong Frog adults. These were not identified, however are likely to be either Booroolong Frogs or Pobblebonks *Limnodynastes terraereginae*, also recorded in the same locations as Booroolong Frogs.

All stream reaches surveyed were adjacent to farm land, or urban development. Booroolong Frogs were not generally recorded at survey sites which had stream banks dominated by fine sediment or mud flats with little rock coverage or crevices. Individuals were not observed in areas heavily infested with weeds (particularly blackberry *Rubus* sp.). However, some individuals were observed in disturbed habitat, sheltering in clumps of aquatic vegetation amongst the sediment and isolated algal dominated pools (photograph 7 and 8) or areas with some weed present (photograph 9 and 10). Five Booroolong Frogs were recorded in areas where stock had access to the river banks (photograph 5 and 6), however the largest numbers of individuals were recorded in a section where stock access had been restricted (photograph 11 and 12).

The European Carp *Cyprinus carpio* was recorded in the stream section of the Macquarie River near Montavella Road and in the stream section closest to Chifley Dam. Carp are known to prey on tadpoles, including the Booroolong Frog (Hunter et al, 2011).

No Booroolong Frogs were recorded at the locations surveyed along Campbells River. Cobble areas immediately downstream of Chifley Dam were degraded by weeds, accessed by cattle, and infilled by silt. Further downstream, the reach of Campbells River inspected was also subject to weed invasion and sedimentation of cobble areas. Weather conditions were similar to the nights either side, when Booroolong Frogs were recorded at the Macquarie River. In addition, no Booroolong Frogs were recorded in the small section of cobble located on the Macquarie River at Bicentennial River Park in Bathurst. This area is also subject to high levels of human disturbance and the species is unlikely to occur at this location.

Incidental observations

Large numbers of Pobblebonks *Limnodynastes terraereginae*, as well as some Common Eastern Froglets *Crinia signifera* and Peron's Tree Frog *Litoria peronii* were recorded in riparian vegetation and agricultural land adjoining the Macquarie River. Portions of the study area where these species were recorded appeared to support local breeding populations of these species.

Occasional Eastern Banjo Frogs *Limnodynastes dumerilii*, Spotted Grass Frogs *Limnodynastes tasmaniensis*, Leseuer's Tree Frogs *Litoria lesueueri*, and Common Eastern Froglets *Crinia signifera* were also recorded in riparian vegetation along the Turon River in Sofala.

Discussion

The localised surveys recorded Booroolong Frogs in numbers that would indicate there is a resident population along the Macquarie River. While frogs were found at discrete locations along the river, the connectivity

provided by the stream and riparian vegetation potentially enables the Booroolong Frog to migrate and interact as a single population or meta-population (Hunter & Smith 2013). Suitable breeding and foraging habitat was recorded at a number of locations during surveys. The results of this survey are generally consistent with our understanding of this species' general ecology. Most individuals observed were located on or near cobble banks or large boulders within the river banks.

The species appeared to largely persist along sections of the stream that are highly modified, supporting what is currently known about this species' current distribution and habitat preferences (DotE, 2016). Many of the reaches along the Macquarie River are open to stock access, heavily infested with weeds, or contain rocky structures that have been substantially reduced by high sedimentation. Increased sediment loads entering the stream has reduced the availability of rocky habitat structures as fine sediments fill the crevices used for shelter, and reduce food availability for tadpoles (Gillespie 2000; Regan 2002). High weed infestation is likely to create surface mats which are also likely to fill available rock crevices (Hunter and Smith 2013).

The Booroolong frog may utilise degraded habitats if adjacent to preferred habitat, and the degree of reliance on such habitats warrants further investigation to discover whether the matrix surrounding the preferred patches is also critically important for managing this species.

Hunter and Smith (2013) suggests that the Booroolong Frog's capacity to cope with high levels of disturbance may be due to its primary habitat requirement being rock structures, which tend to remain intact even after vegetation removal. However, disturbance and habitat modification are not conducive to the long-term persistence of the Booroolong Frog, with increasing fragmentation attributed to reduced population density and increased susceptibility to stochastic events (Hunter 2007). This may have been the case in locations where the species was not recorded; it is possible that disturbance is

too great at these locations, and the frog no longer occurs.

The protection of rocky habitat along the stream is critically important for the longevity of Booroolong Frog populations. Minimising sediment loads entering the streams and controlling invasive weeds are important actions to protect habitat. Increased sedimentation is likely to result from inappropriate use of machinery in the riparian zone, vegetation removal, erosion from livestock or poor road construction. Weed infestation substantially reduces available breeding habitat, and a control/eradication program for weeds will benefit breeding habitat for the species (DotE, 2016 and Hunter and Smith, 2013).

Management measures to improve habitat values and minimise potential for further degradation include weed control programs along the Macquarie River, restriction of access of livestock to the Macquarie River and appropriate revegetation of riparian areas with native flora species.

Further surveys of the Macquarie River, Fish River and Campbells River near Bathurst and the Turon River near Sofala are also recommended to increase understanding of the numbers and distribution of the Booroolong Frog in these localities. This will lead to a better understanding of the habitat type and condition required by the species and assist with future management considerations for the species generally.

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